College of Food, Agricultural, and Environmental Sciences/ Department of Food, Agricultural, and Biological Engineering

Obtaining Uniform Distribution of Granular Fertilizers with a Spinner Disc Spreader in Variable Rate Scenarios

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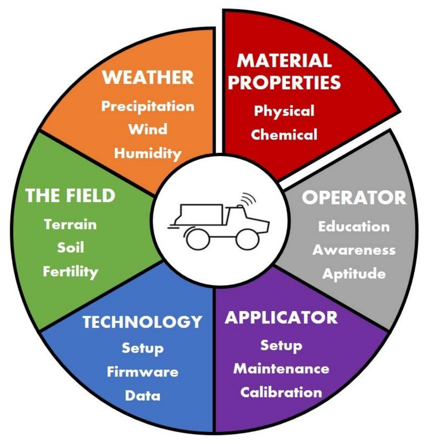
INTRODUCTION



Broadcast granular fertilizer distribution with dual spinner-disc spreaders are a popular option for nutrient application in the United States. These spreaders provide an efficient and cost-effective method of crop fertilization, and through wide swath widths (~21-30 m) are capable of meeting the high field capacity (ac/hr) demands of current agricultural producers. These broadcast applicators allow for products to be applied as individual constituents in a dual bin system, or as a single fertilizer blend in a one bin system. Additionally, each of these products can be metered at a variable rate depending on the agronomic need of the field. Due to the variation in fertilizer sources and/or rates, the blend of materials that is delivered the spinner-discs is constantly changing. Because this blend changes and spreader settings remain the same, irregularities in spread uniformity can arise. These errors in uniformity are undesirable for ideal crop performance (Jensen and Pesek, 1962). Independently metered fertilizers are assumed to be distributed similarly to those in the blended form. Further research is needed to evaluate different blended fertilizers that are applied with spinner-disc spreaders (Virk et al., 2013) . However, distribution variability based on method by which product is metered has not been studied.

AIM

1. Evaluate possible Phosphorus pattern differences whether metered alone, independently with Potassium, or in a blend.
2. Determine total pattern differences of a Phosphorus-Potassium application whether metered independently, or in a blend.

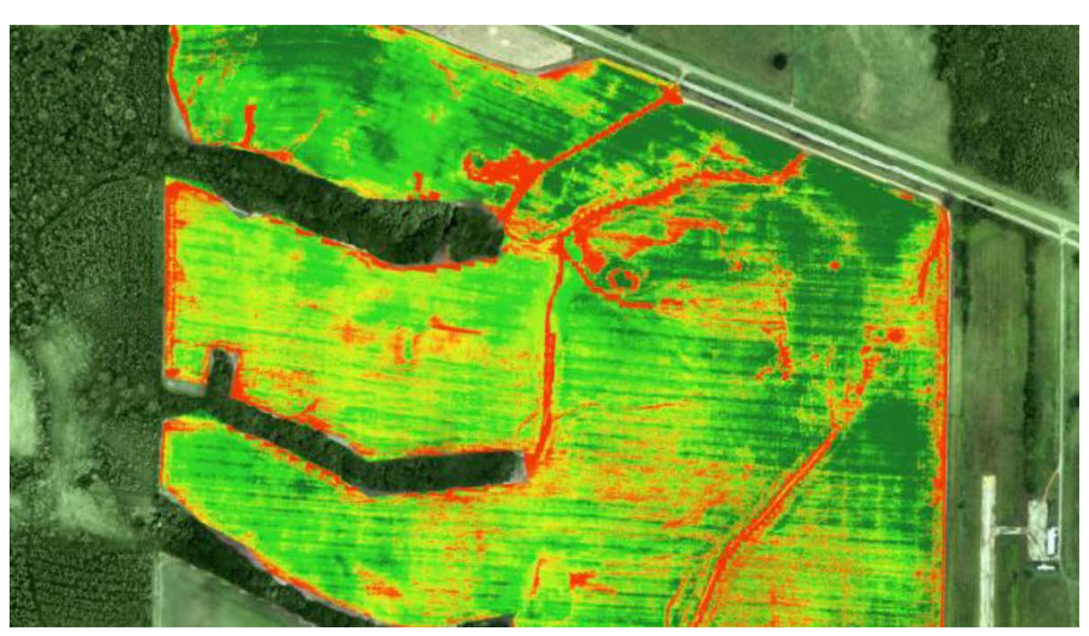


Figure 1. Variations in observed crop health caused by a non-uniform spinner-disc spreader application.

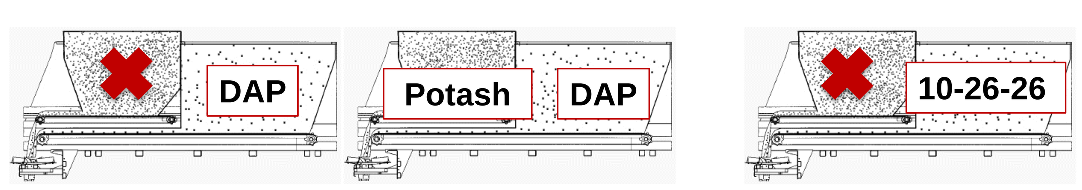
METHODS

Test Design

All spread pattern analyses were conducted in accordance with ASABE S341.4 & ISO 5690-1:1985 standards. Collection pan spacing was 0.8 m and test areas were extended to twice the width of the target swath. A New Leader L428G4 MultApplier Bed self-propelled spreader was used for all tests. Figures 2 and 3 below illustrate the pan testing layout, bin configurations, and test loadings, respectively.

Figure 2. New Leader L428G4 MultApplier Bed self-propelled spreader used for all fertilizer uniformity tests (a). Multi-product bin with Potash and DAP Fertilizer constituents loaded (b).

Test set-up is provided below, these applications were conducted in a way to minimize the variability of spread. Fertilizers were sourced from a local cooperative and transported to the field in the form of the constituents. Blends were mixed at the edge of the field so that they would not segregation of particles.



Test 1: DAP Only
253 kg/ha (226 lbs/acre)

Test 2: Ind. Metered
448 kg/ha (400 lbs/acre)
-DAP = 253 kg/ha
-Potash = 195 kg/ha

Test 3: Blended Only
448 kg/ha (400 lbs/acre)
-DAP = 253 kg/ha
-Potash = 195 kg/ha

Figure 3. Testing Bin Configurations and Application Rates.

Material Properties

Randomized samples were collected from spreader bins prior to testing, particle analysis was conducted on each sample. Table 1 summarizes the physical properties of these fertilizers:

	Formulation (N-P-K)	Bulk Density (g/cm^3)	D_{50} (mm)[2]	GSI[2]
DAP	18-46-0	1.01	2.9	18.1
Potash	0-0-60	1.11	2.9	22.4
Blend[1]	10-26-26	1.03	2.9	20.7

[1]Fertilizer blends were mixed using DAP and Potash fertilizers
[2]D_{50} = median particle size, GSI = Granulometric Spread Index

RESULTS

Test 1: DAP Only, Single-pass Mean Patterns

Spread patterns for the DAP component of all three fertilizer loadings were analyzed for uniformity. For the target application rate of 253 kg/ha, a "W" shaped spread pattern was observed within the 30 m target swath.

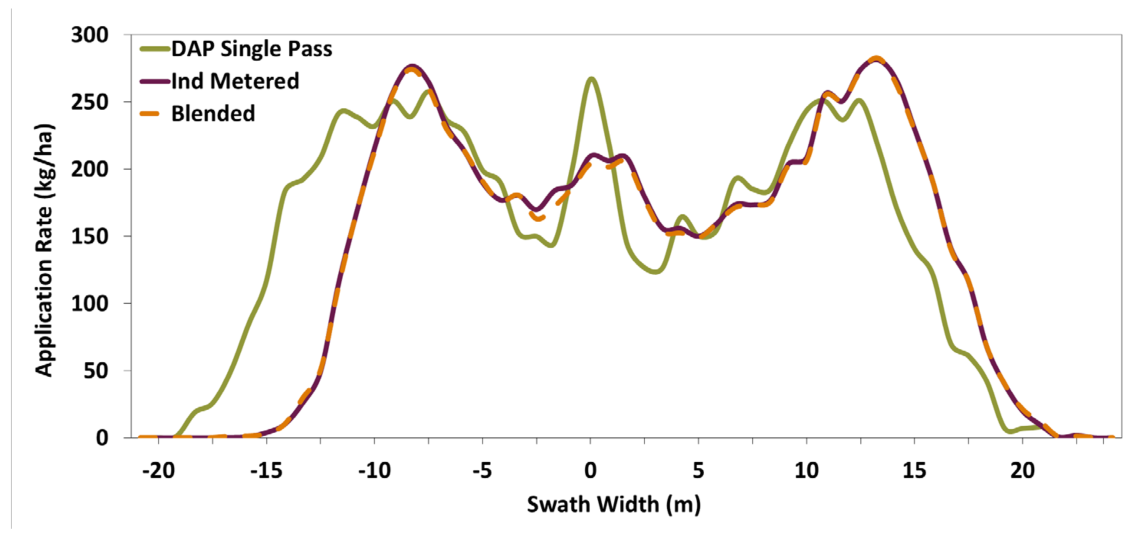


Figure 4. DAP component application rates all fertilizer sources.

Test 2: Dual Product, Independently Metered

Generally, the DAP components of the fertilizer source were spread further away from the centerline of the spreader, while the potash components were found closer to the centerline of the spreader. This effect may be attributed to the intrinsic ballistic properties of the fertilizer blend rather than preset spreader settings.

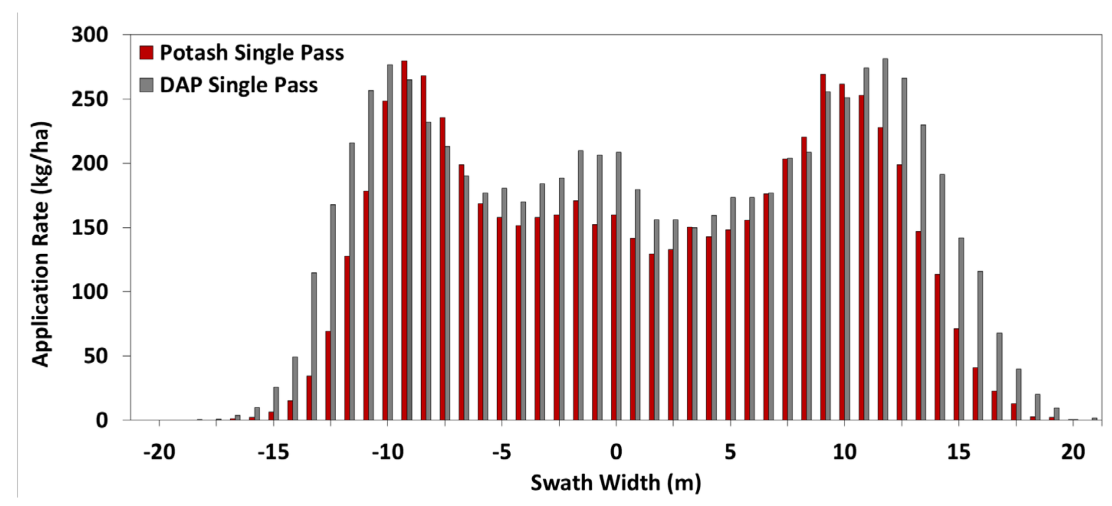


Figure 5. Single-pass application rates for independently metered application.

Test 3: Dual Product, Blended

Generally, the DAP components of the fertilizer source were spread further away from the centerline of the spreader, while the potash components were found closer to the centerline of the spreader. This effect may be attributed to the intrinsic ballistic properties of the fertilizer blend rather than preset spreader settings.

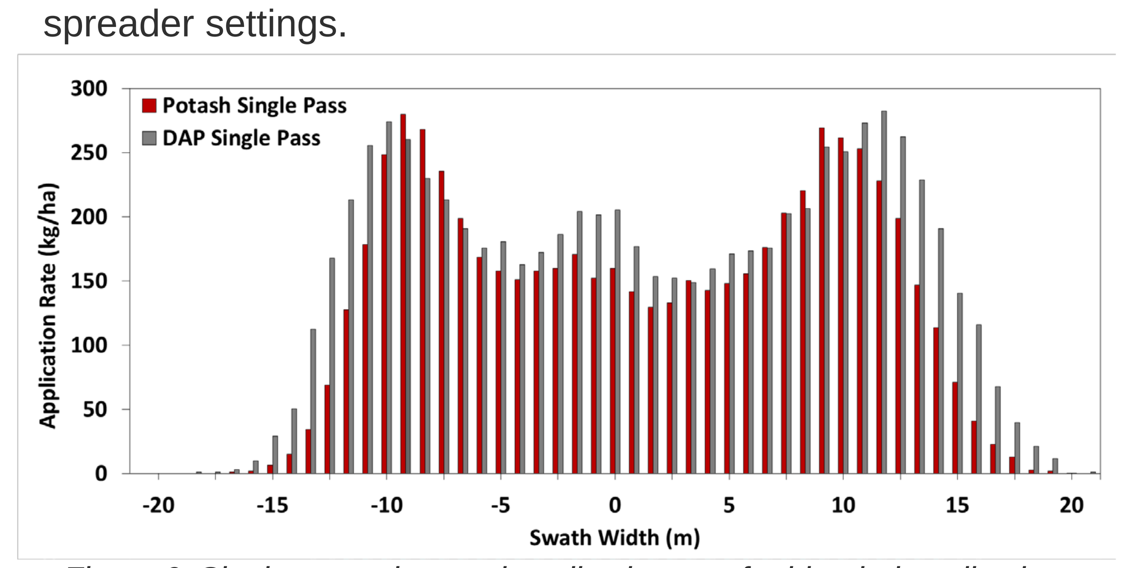


Figure 6. Single-pass observed application rate for blended application.

CONCLUSIONS

Overall, the distribution of P_2O_5 and K_2O fertilizers was consistent between metering type (R = 0.98). The differences in spread pattern between P_2O_5 and K_2O can be attributed to the material properties discussed in Table 1, and observable in Figure 6. These properties, such as size, shape, and density, have a large effect on the observable spread pattern in a field.

It is important to consider these changes in product properties and blends as an applicator travels across the field. In order to achieve maximum efficiencies, spreader settings must change as the source or rate changes.

Test 1: Variability in the phosphorus patterns between the DAP only fertilizer source and both the independently-metered and blended fertilizer sources indicate the need for adjustment of spreader settings before changing products.

Tests 2 & 3: Pan collection analysis for both the independently-metered and blended fertilizer sources indicated minimal variability (R = 0.98) between metering type as related to measured ratio of P_2O_5:K_2O collected in each pan. This indicates the spread variability is not a function of metering.

KEY FINDINGS:

1. ***Segregation is prevalent, but not at fault of metering***
(need to rethink spreader settings)
2. ***Phosphorus pattern differences when encountering product changes***
(need ability to adjust in VRT situations)

FUTURE WORK

Various rates, sources, swath widths, and spreaders should continue to be evaluated in order to fully understand how different material properties affect fertilizer distribution uniformity.

Achieving high levels of accuracy in a VRT independently metered system, requires spreader settings to be adjusted on a sub-field basis.

REFERENCES

Jensen, D., & Pesek, J. (1962). Inefficiency of Fertilizer Use Resulting from Nonuniform Spatial Distribution *Soil Science Society of America Journal*, *26*(2), 178.

Virk et al., (2013). Case study: Distribution uniformity of a blended fertilizer applied using VRT spinner-disc spreader. *Applied Engineering in Agriculture*, *29*(5), 627–636.

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